

# The Osteology and Classification of the Ophichthid Eels of the Hawaiian Islands<sup>1</sup>

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## INTRODUCTION

THE CLASSIFICATION of the eels of the family Ophichthidae is, as Myers and Storey (1939: 156) put it, in the utmost confusion. Their suggested solution, with which I heartily concur, is a sound anatomical study of all the included genera. This cannot be undertaken in the present paper as the family is of circum-tropical distribution and many of the genera are unavailable to me. Nevertheless, a rather large and representative group of these eels is present in the Hawaiian Islands. The osteology of the most divergent of these has been investigated in the hope of providing at least a basis for work on ophichthid relationships. The results of this study and of two others already completed (Gosline, 1950, and in press) have borne out the necessity for the entire realignment of the Ophichthidae which Myers and Storey (1939: 157) predicted.

The taxonomic section of this paper deals with all species of ophichthid eels recorded from the Hawaiian Islands (including Johnston Island). One new genus, one new subgenus, and two new species are described, and a substitute specific name is proposed. These are as follows.

Genus: *Phyllophichthus*

Subgenus: *Schultzidia*

Species: *Phyllophichthus xenodontus*

*Caecula* (*Sphagebranchus*) *platyrhyncha*

*Myrichthys bleekeri* (to replace *M. semicinctus*)

The paper is concluded with a brief discussion of the distribution of Hawaiian ophichthids.

However, before dealing with these matters, the use of the name Ophichthidae for this family needs explanation. The genus *Ophichthus* (Thunberg and Ahl, 1789: 5) was corrected by nineteenth-century classicists to *Ophichthys*, and the family was called Ophichthyidae. In recent years ichthyologists have returned to the original spelling of the generic name but have retained the emended form of family name. This is illogical and nomenclatorially incorrect. A more serious difficulty arises from the fact that the first family name proposed for the group is Ophisuridae (M'Clelland, 1844: 211). However, whether or not *Ophisurus* is a valid genus is a moot nomenclatorial question. Consequently I prefer not to use for this family, at the present time, the little-known and possibly invalid name Ophisuridae.

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# OSTEOLOGY

The most diverse of the Hawaiian ophichthids were selected for osteological study. In general the heads, branchial arches, and pectoral girdles were stained with alizarin and dissected; in *Brachysomophis henshawi* the right side of the head of the only available specimen (and apparently the third known) was dissected without staining. The bodies of the fishes studied were X-rayed, though some specimens were stained and rather unsuccessfully cleared. The species studied in this manner were as follows:

## Subfamily MYROPHINAE

*Muraenichthys* (*Muraenichthys*) *cookei* (Figs. 3, 10a, 12b, 13).

## Subfamily OPHICHTHINAE

*Caecula* (*Sphagebranchus*) *platyrhyncha* (Figs. 1, 14b,d).

*Myrichthys maculosus* (Figs. 5, 7-9, 15b).

*Cirrhimuraena macgregori* (Figs. 6, 10b, 16).

*Leiuranus semicinctus* (Figs. 4, 17c).

*Brachysomophis henshawi* (Figs. 2, 18).

**LATERAL LINE SYSTEM OF HEAD AND ASSOCIATED BONES.** The pattern of the lateral line system of the head in the Ophichthidae has already been described in considerable detail for "*Ophichthys serpens*" by Allis (1903: 126) and is illustrated here in Figures 1 and 15. It is quite uniform in the species studied.

On the other hand, the degree of development of many of the bones through which the canals pass varies considerably. The canals are enclosed in a series of bony ossicles except where they penetrate the pterotics, frontals, and dentary. These ossicles may be small, separate, bony cylinders; they may be united into more or less elongate tubes; or such a tube may be expanded into a bone of considerable extent. In *Brachysomophis* the ossification of the lateral line system is the most complete (Fig. 2a). In that genus the nasal as usual is well developed; in addition the postorbitals form a strong strut for the support of the maxillary, the suborbitals form

a tube closely appressed against the maxillary, the preopercle is laminated, and a small

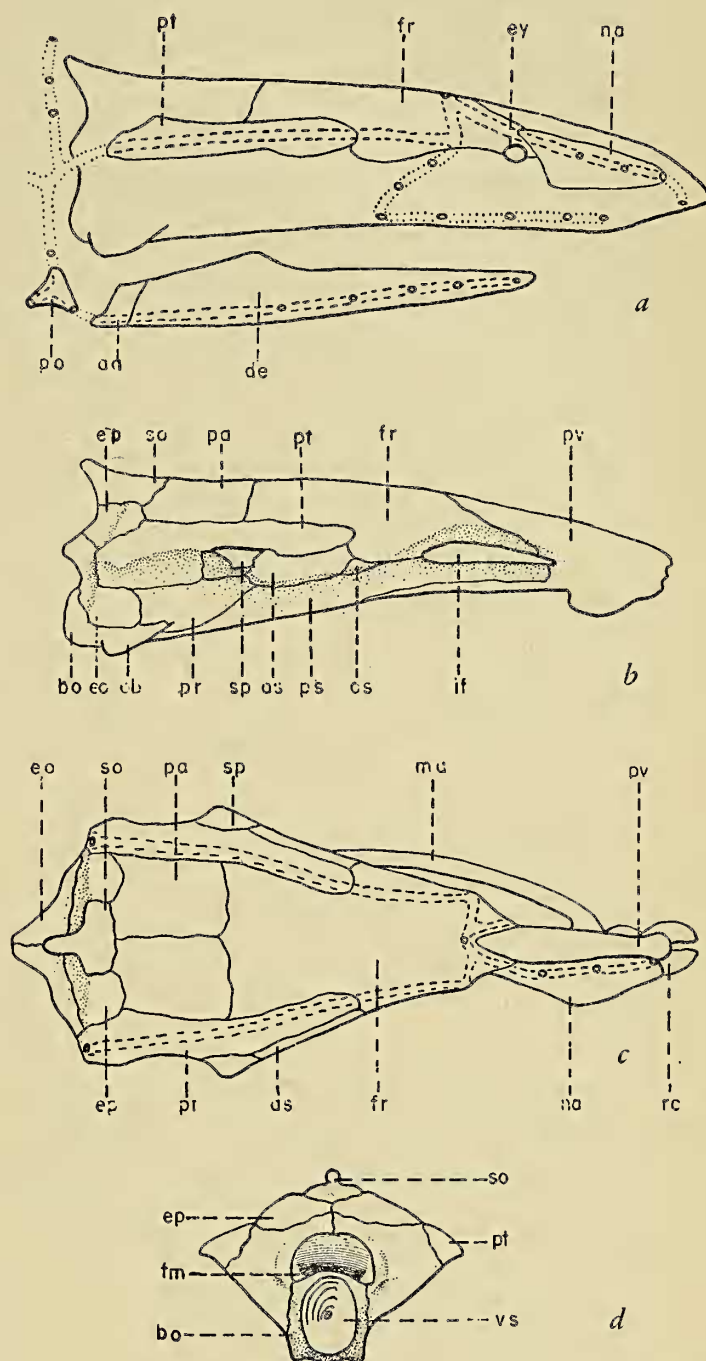


FIG. 1. *Caecula* (*Sphagebranchus*) *platyrhyncha*. a, Right side of head, showing lateral line canals and pores. Canals passing through bony ossicles dotted; canals passing through head bones dashed and the outlines of such bones indicated. aa, Articular-angular; de, dentary; ey, eye; fr, frontal; na, nasal; po, preopercle; pt, pterotic. b, Right side of cranium. Teeth omitted in this and most of the following figures. as, Alisphenoid; bo, basioccipital; eo, exoccipital; ep, epiotic; fr, frontal; if, interorbital opening; ob, otic bulla; os, orbitosphenoid; pa, parietal; pr, prootic; ps, parasphenoid; pt, pterotic; pv, premaxillary-ethmo-vomer; so, supraoccipital; sp, sphenotic. c, Cranium from above. Lateral line canals of cranial bones drawn in. The nasal (na) is included on the right side, the maxillary (ma) on the left, and the rostral cartilages (rc) in front. Other labels as in Fig. 1b. d, Skull from rear. Bones labeled as in Fig. 1b. fm, Foramen magnum; vs, socket for centrum of first vertebra.



lacrymal appears to be developed. In other genera examined the circumorbitals are reduced to a series of ossicles enclosing the infraorbital canal, and the preopercle is usually almost rudimentary.

**OPERCULAR APPARATUS.** The opercular apparatus shows various degrees of reduction in the ophichthids examined. In general, the body of the operculum lies mostly or entirely below its articular facet, though it projects upward to a considerable extent in *Brachysomophis* (Fig. 2a) and, to some extent, in *Caecula*. The suboperculum and interoperculum are wedge-shaped bones, but in *Muraenichthys* the suboperculum (Fig. 3a) sends out a backward projection that encloses the lower edge of the operculum. The preoperculum is moderately developed in *Brachysomophis*, *Leiuranus*, and *Cirrhimuraena*, or is reduced to a tube for the lateral line canal in *Muraenichthys* and *Caecula*. In general, it may be said that the opercular system of *Brachysomophis* is the least, and that of *Muraenichthys* the most, specialized (or degenerate).

**SUSPENSORIUM.** The suspensorium of *Muraenichthys* (Fig. 3a) differs from that of the other species examined in being somewhat for-

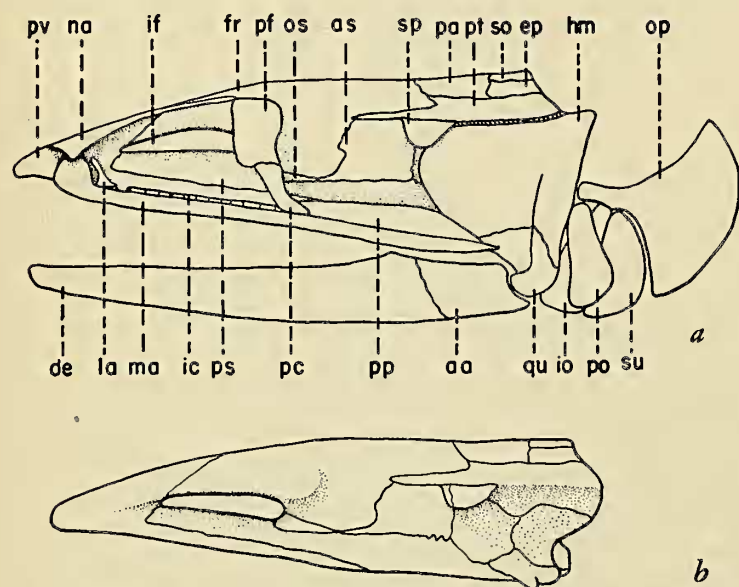


FIG. 2. *Brachysomophis henshawi*. a, Bones of left side of head. hm, Hyomandibular; ic, infraorbital canal; io, interopercle; la, lacrymal?; ma, maxillary; op, opercle; pc, enlarged postorbital ossicle; pf, post-frontal; po, preopercle; pp, palatopterygoid; qu, quadrate; su, subopercle. Other labels as in Fig. 1b. b, Skull from left. Bones as in Fig. 1c.

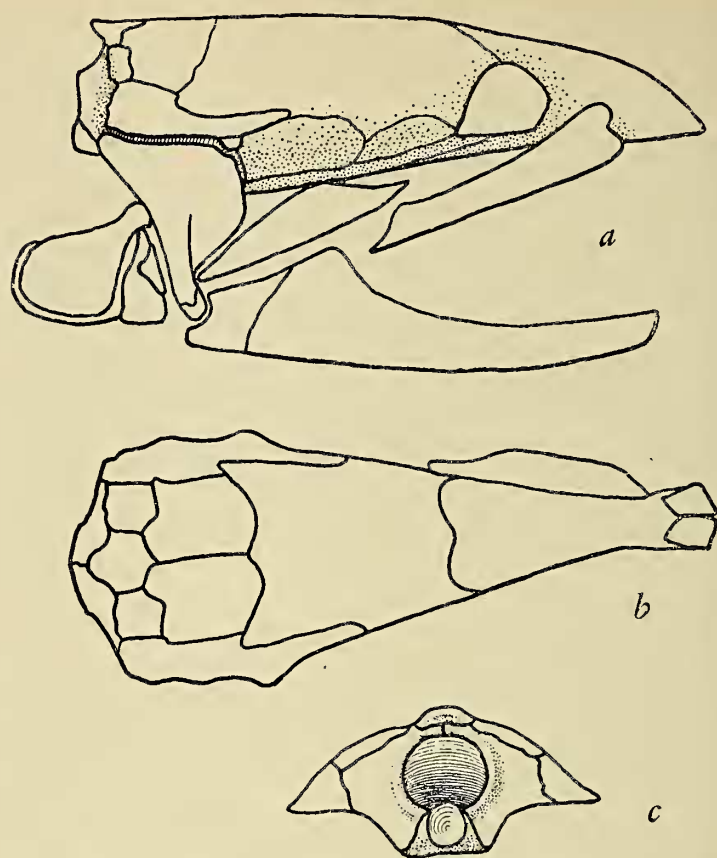


FIG. 3. *Muraenichthys (Muraenichthys) cookei*. a, Head bones from right. Bones as in Fig. 2a. b, Skull from above. Nasal included on left side. Bones as in Fig. 1c. c, Skull from rear. Bones as in Fig. 1d.

wardly inclined. In all, the palatopterygoid is a laminar bone more or less loosely attached to the hyomandibular and quadrate posteriorly, and by ligament to the maxillary laterally and the skull mesially.

**LOWER JAW.** The lower jaw is inferior to the upper except in *Brachysomophis* (Fig. 2a) where it projects and, like the upper, bears large, sharp canine teeth.

**MAXILLARIES.** The maxillaries articulate at a more or less variable distance from the tip of the rostrum, far forward in *Brachysomophis* (Fig. 2a), more posteriorly in the others. Usually the dentigerous part of the maxillaries terminates well forward of the highest part of the dentary, though an ossified ligament may extend farther back. In *Brachysomophis*, however, the maxillary is a long, toothed bone extending back almost to the level of the lower jaw articulation; it is supported above, as already noted, by the postorbitals.

Another type of jaw specialization is found



in *Leiuranus*. Here the two maxillaries have moved toward each other across the roof of the mouth until their forward ends abut against one another (Fig. 4*b*).

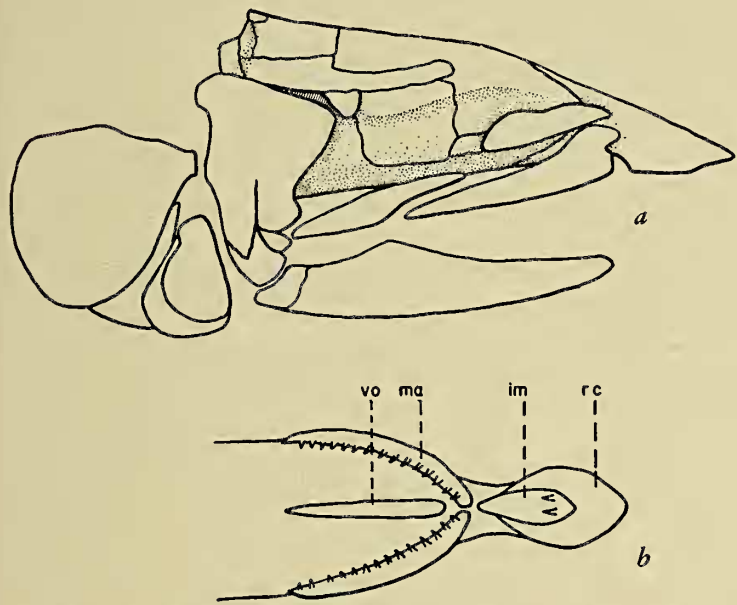


FIG. 4. *Leiuranus semicinctus*. *a*, Head bones from right. Bones as in Fig. 2*b*. *b*, Bones of roof of mouth from below, semidiagrammatic. Teeth indicated. im, Intermaxillary area of premaxillary-ethmo-vomer; ma, maxillary; rc, rostral cartilage; vo, vomerine area of premaxillary-ethmo-vomer.

**SKULL.** In the cranium of the species examined the greatest difference is between *Myrichthys* and the others. In *Myrichthys* (Fig. 5) the snout is blunt and rounded and the skull is short and high. The interorbital opening seems to have been compressed from front to rear and is elongate vertically. The orbito-sphenoids are large, apparently filling that part of the skull wall left by the withdrawal upward of the frontals. In the other genera the interorbital opening is always longer than high. In those species with especially long, low skulls, e. g., *Caecula platyrhyncha* and *Brachysomophis henshawi*, the opening is almost slitlike, whereas in those with a moderately high skull, e. g., *Muraenichthys cookei* and *Cirrhimuraena macgregori*, it is more rounded. In all but *Myrichthys* the orbitosphenoid appears to be more or less squeezed out externally by the frontals above and the parasphenoid below.

In most of the Ophichthidae the ethmoid projects up over the dorsal surface of the

frontals as a subtriangular median wedge (Fig. 1*c*). However, in *Myrichthys* (Fig. 5*b*) and *Muraenichthys* (Fig. 3*b*) the projection is broad and bilobed.

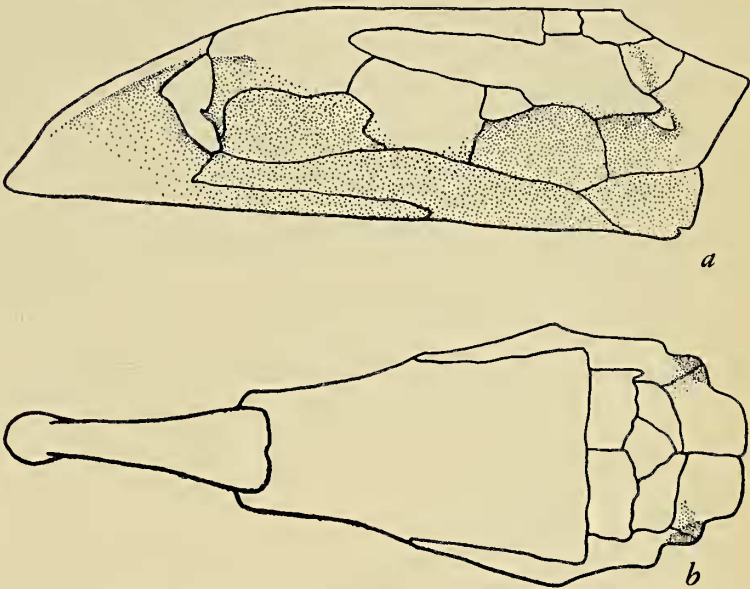


FIG. 5. *Myrichthys maculosus*. *a*, Cranium from left; *b*, from above. Bones as in Fig. 1.

In all the ophichthids examined, auditory bullae are developed as bulges on the ventral surface of the skull. These bullae are formed from parts of the basioccipitals, exoccipitals, and prootics. Axial muscles from the body attach especially to the basioccipitals which, in *Brachysomophis*, form a distinct lobe for this purpose (Fig. 2*b*). Auditory bullae are least prominent in *Cirrhimuraena* (Fig. 6*b*).

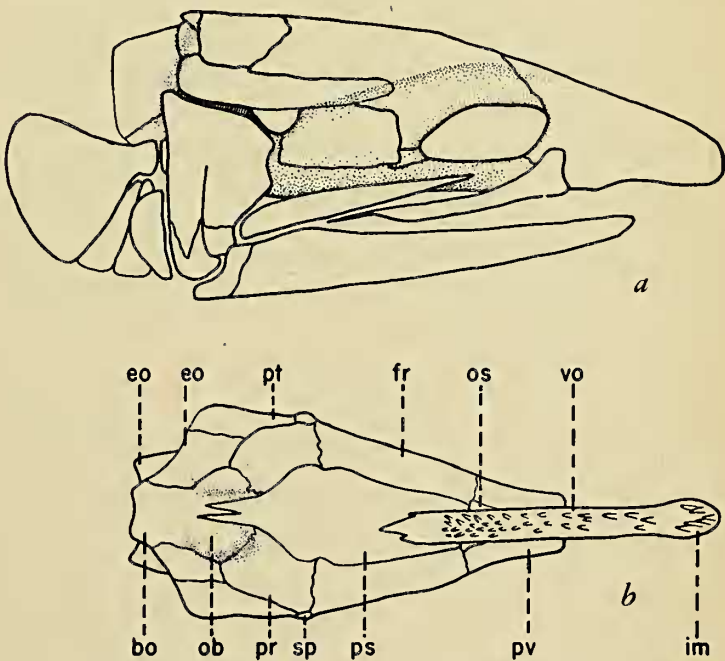


FIG. 6. *Cirrhimuraena macgregori*. *a*, Head bones from right. Bones as in Fig. 2*a*. *b*, Skull from below. Teeth shown. Labels as in Figs. 1*b* and 4*b*.



The skulls of the six genera examined also vary in the distance they project behind the supraoccipital. In *Brachysomophis* the skull is relatively truncate behind; in *Myrichthys*, at the other extreme (Fig. 5), a rather large section of the skull lies behind the supraoccipital.

**GILL ARCHES.** The gill arches of species of *Muraenichthys*, *Leiuranus*, *Ophichthus*, *Pisodonophis* ("Ophichthus boro"), and *Myrichthys* ("Ophichthus colubrinus") have been briefly dealt with by Popta (1906). The gill arches of *Myrichthys maculosus* are illustrated in Figure 7.

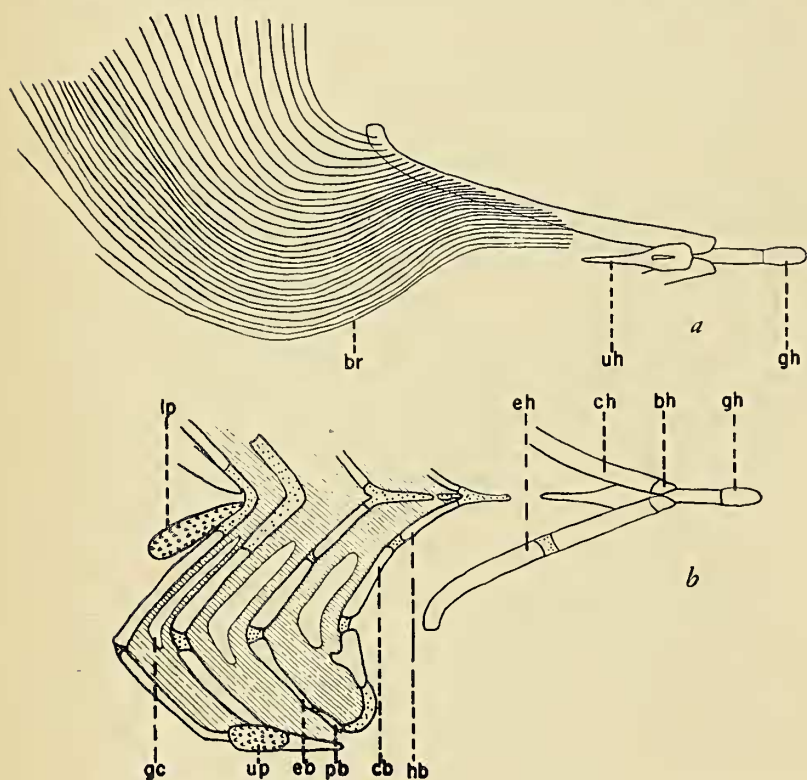


FIG. 7. *Myrichthys maculosus*. *a*, Outline of right side of hyoid apparatus from below. br, Branchiostegal ray; gl, glossohyal; uh, urohyal. *b*, Right gill arches from above, the upper parts opened out. Branchiostegal rays not shown. Cartilage areas stippled. bh, Basihyal; cb, ceratobranchial; ch, ceratohyal; eb, epibranchial; eh, epihyal; gc, gill cleft; gh, glossohyal; hb, hypo-branchial; lp, lower pharyngeal; pb, pharyngobranchial; up, upper pharyngeal.

Within the forms examined, the number of branchiostegal rays on one side are as follows: *Caecula platyrhyncha*, 17; *Brachysomophis*, 18; *Cirrhimuraena*, 24; *Muraenichthys cookei*, 26; *Leiuranus*, 28; and *Myrichthys maculosus*, 32. In all of these the branchiostegal rays of the two sides of the head overlap broadly on the midventral line.

The pharyngeal teeth in all of these forms

except *Myrichthys* are small, sharp, and depressible; in *Myrichthys* they are blunt and little movable. In all, the upper pharyngeals are shorter and broader than the lower, most notably so in *Brachysomophis*. In *Muraenichthys*, *Leiuranus*, and *Brachysomophis* the lower pharyngeals are elongate and biserial; in the other three genera they are club-shaped to ovate. The number of teeth on a pharyngeal varies from 18 to 34 in the different forms.

**PECTORAL GIRDLE.** The pectoral girdle seems always to be represented. Judging from X rays it is reduced to a cleithrum and possibly a supracleithrum in *Caecula*. In *Myrichthys* a rudimentary bone which is probably the coracoid (Fig. 8) is embedded in a cartilaginous plate. In *Cirrhimuraena*, scapula, coracoid, and a single actinost are present as well as cleithrum and supracleithrum.

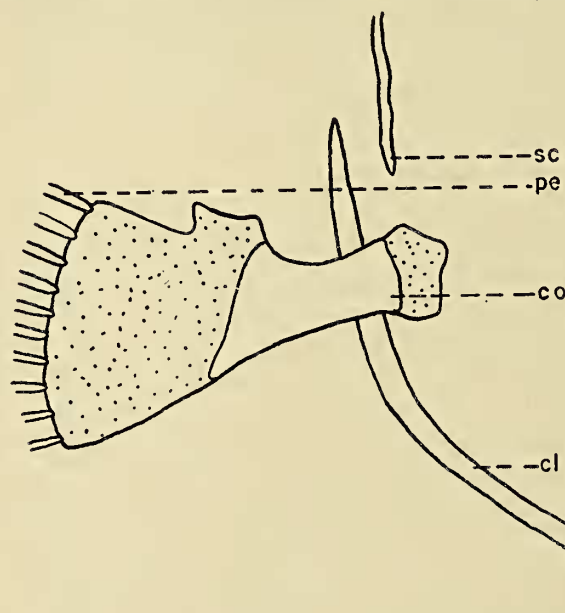


FIG. 8. *Myrichthys maculosus*. Left half of pectoral girdle from inside. Cartilage areas stippled. cl, Cleithrum; co, coracoid?; pe, base of pectoral ray; sc, supracleithrum.

**AXIAL SKELETON.** Inasmuch as the nature of the vertebral column cannot be properly illustrated in its entirety, and as it has been used as a basis of family definition by Regan (1912: 386), it must be described in a general way. The following account is based primarily on *Myrichthys*, *Brachysomophis*, and *Caecula*. The first centrum is not fused to the skull; it is short, and its neural arch extends backward over the centrum of the second



vertebra (Fig. 9a). At about the sixth vertebra the centra develop, ventrally, broad lateral flanges that continue to the anus (Figs. 9b,c). These are replaced in the caudal vertebrae by strong transverse processes above the haemal arches (Fig. 9d). Neural spines are undeveloped except often as small backward projections from a few anterior vertebrae. Epineurals and epipleurals are developed in each anterior segment starting from the anterior part of the column or basioccipital (Fig. 9a-d). Pleural ribs are present along most of the column and may be distinctly laminate (Fig. 9b,c). Epipleurals, epineurals, and pleural ribs extend outward and backward for most of the length of the fish. However, in the tail region these structures are replaced by a series of intermuscular bones, four to each vertebra, extending outward and forward (Fig. 10b). *Muraenichthys* lacks such intermuscular bones. Otherwise, the vertebral column in the species studied appears to be rather uniform.

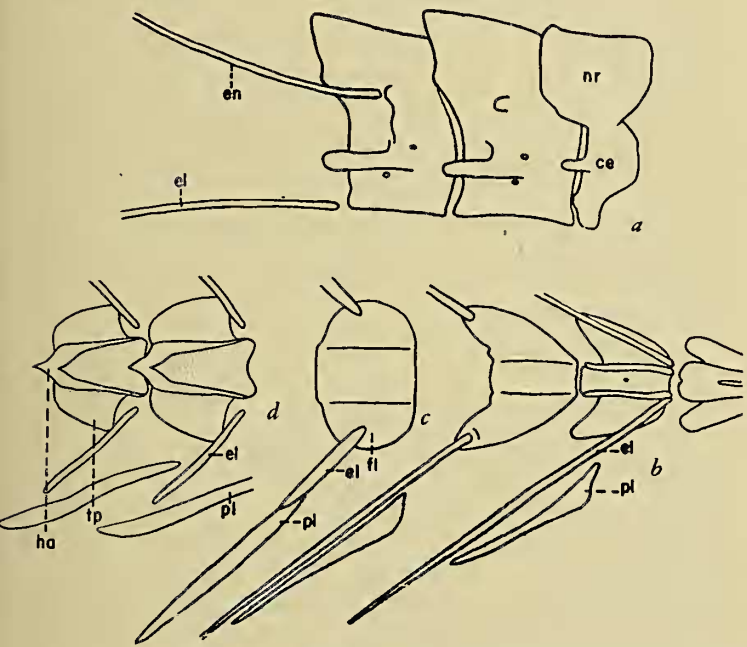


FIG. 9. *Myrichthys maculosus*. a, First three vertebrae from right. Epineurals and epipleurals are omitted from first two. ce, Centrum; el, epipleural; en, epineural; nr, neural arch. b, Vertebrae 4-6; c, vertebra 26; d, two anterior caudal vertebrae from below. el, Epipleural; fl, lateral flange of centrum; ha, haemal arch; pl, pleural rib; tp, transverse process of centrum.

The total numbers of vertebrae for several ophichthids are shown in Table 1. Lateral-line pore counts for the body were also made

(Table 1) in the hope that these might prove indicators of vertebral number. In a general way, such is the case. The discrepancies between pore counts for the body and the number of vertebrae is probably due, at least in part, to the fact that lateral line pores stop short of the tip of the tail, notably so in *Brachysomophis*. For example, in *Cirrhimuraena macgregori*, with a vertebral count of 181 and with 172 pores, the last pore is over the 171st vertebra.

TABLE 1  
VERTEBRAL NUMBERS AND PORE COUNTS IN CERTAIN OPHICHTHIDS

SPECIES	NUMBER OF VERTEBRAE	PORES IN LATERAL LINE
<i>Caecula platyrhyncha</i> .....	120	120
<i>Brachysomophis benshawi</i> .....	130	111
<i>Muraenichthys cookei</i> .....	130	122
<i>Caecula flavicauda</i> .....	153	153
<i>Leiuranus semicinctus</i> .....	168	158
<i>Machaerenchelys phoenixensis</i> ..	169	163
<i>Phyllophichthus xenodontus</i> .....	170	160
<i>Myrichthys maculosus</i> .....	178	162
<i>Cirrhimuraena macgregori</i> .....	181	172
<i>Callechelys luteus</i> .....	213	208

TAIL. In the past *Muraenichthys* has been placed in a different family from the other genera studied here. The sole reason for this is that *Muraenichthys* has a rudimentary fin around the tip of the tail, whereas the others have the tail protruding as a fleshy point. Osteologically, the difference between the tails of *Muraenichthys* (Fig. 10a) and *Cirrhimuraena* (Fig. 10b) is less than that between those of *Cirrhimuraena* and *Caecula platyrhyncha*. Rudimentary rays are present around the tails of both *Muraenichthys* and *Cirrhimuraena*; they are merely embedded in flesh in *Cirrhimuraena* (as also in *Myrichthys*). In *Caecula platyrhyncha*, on the other hand, there are no rudimentary rays either around the tip of the tail or elsewhere. It is obvious from this discussion and more obvious from Figure 10 that a separate family cannot be maintained for *Muraenichthys* on the basis of tail structure.



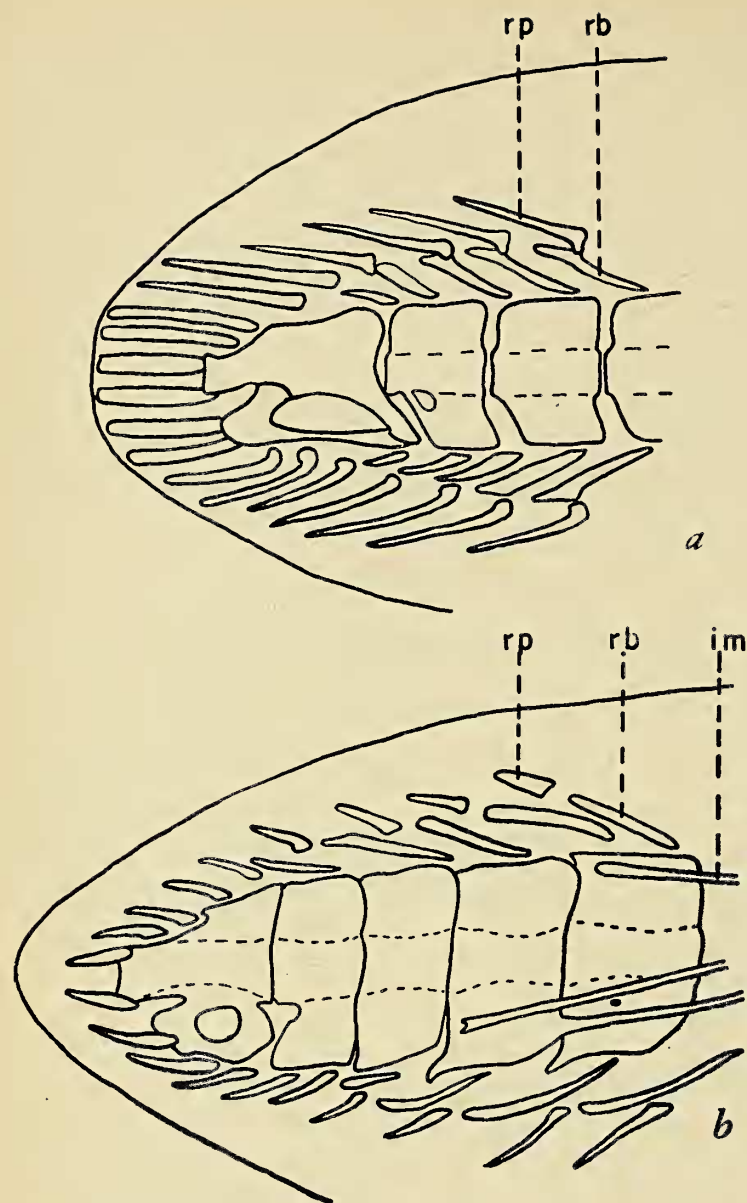


FIG. 10. *a*, Tail of *Muraenichthys* (*Muraenichthys*) *cookei*; *b*, of *Cirrhimuraena macgregori*. im, Intermuscular bone; rb, basal segment of fin ray; rp, peripheral segment of fin ray.

#### DIAGNOSIS AND RELATIONSHIPS

Compared with other eel families the most diagnostic features of the Ophichthidae appear to be as follows:

Dorsal and anal rays either reduced or absent at tip of tail. Posterior nostril below the level of the eye, either on the inside or the outside of the upper lip. Skull not truncate behind. Frontals fused to form a single bone. Suspensorium nearly or quite vertical. Auditory bullae present. Branchiostegal rays of the two sides of the head broadly overlapping on the mid-ventral line. Neural spines rudimentary. Intermuscular bones well developed. Strong transverse processes on caudal vertebrae.

Since the appearance of Regan's excellent paper on eel classification (1912), it has been generally agreed that the Ophichthidae are a specialized offshoot of the congrid stock. Nevertheless, it is necessary here to compare the ophichthids and congrid, partly because no adequate comparison of the two groups exists, and partly to indicate the nature of the specializations in the Ophichthidae.

The ophichthids differ immediately in two superficial characters—the labial nostril and the reduced or absent tail fin. However, these characters are not as significant as they might appear to be.

In the Congridae the posterior nostril opens out in the cheek in front of the eye. A posterolateral deflection of this opening would place it where it occurs in the ophichthid *Caecula flavicauda* (Fig. 14*a*). In those ophichthids that have the narial opening inside the upper lip, the posterior nostril is carried down in a tube (outside the infraorbital canal, as pointed out by Allis [1903]) over the surface of the upper lip and into the mouth. Often the groove behind this tube is still visible externally, as in *Myrichthys* (Fig. 15), but sometimes the tube has been completely fused into the lip. This same specilization of an internal posterior nostril occurs in the unrelated family provisionally called Echelidae (Gosline, 1950).

The reduction or loss of fin rays at the tip of the tail is probably an adaptation to digging, as pointed out by Myers and Storey (1939: 157). That such loss is secondary is shown by the presence of reduced fin rays around the tail of Myrophinae (Fig. 10*a*) and the fin rudiments that remain in certain Ophichthinae (Fig. 10*b*).

Osteologically, *Conger* (Fig. 11) shows numerous characters in which it is undoubtedly more primitive than the Ophichthidae. In most of these it resembles the Anguillidae. However, the Congridae and the Anguillidae differ at once in that the frontals of the Anguillidae are separate, whereas those of the Congridae are fused into a single bone. Pri-





FIG. 11. Head bones of *Conger vulgaris*, after Goodrich.

marily because of this difference, Regan (1912) has, by implication, postulated these two families as being near the starting points of the two main lines of eel evolution. The ophichthids belong in the congrid line.

In *Conger* the suspensorium is well developed and its bones are well integrated, i. e., the palatopterygoid is united by suture with both the quadrate and the hyomandibular. The opercular bones are all large and well developed for eels. The branchiostegals are few (9-9), and those of the two sides do not overlap on the mid-line. The large basihyal projects into the free tongue. These are all primitive characters as compared with the Ophichthidae. *Conger* and *Anguilla* agree in having the skull long and low (this does not seem to me to be a necessarily primitive feature) and in certain associated bone arrangements, i. e., the interorbital opening, alisphenoids, and pterotics are longitudinally elongate, and the orbitosphenoid is small or absent externally. Unlike most ophichthids, but like *Anguilla*, *Conger* has the suspensorium forwardly inclined, and has the intermaxillary and vomerine teeth in an almost continuous series. Unlike most eels that I have examined, including the ophichthids, *Conger* lacks the cross commissure of the lateral line system in the frontals that gives rise to a middorsal pore.

The head skeleton of the Ophichthidae differs from that of *Conger* in four principal ways: (1) there has been a further reduction in the size and strength of certain of the skull bones; (2) the suspensorium has become nearly or

quite vertical; (3) the branchiostegal rays have developed a basketlike arrangement on the throat; and (4) an auditory bulla is present.

The bones that have undergone further reduction are the palatopterygoid, the elements of the opercular series, and the preorbital.

It is impossible to say, but seems probable, that the change from a forwardly inclined suspensorium in *Conger* to the nearly vertical one of the Ophichthidae is functionally related to the inferior mouth of most ophichthids. At any rate, in *Conger* much of the adductor muscle of the mandible runs upward and backward to attach to an aponeurosis on the posterodorsal angle of the skull. In the Ophichthidae (with a vertical suspensorium and a more posterior articulation of the mandible) the adductor muscles run more directly up over the skull, and the posterodorsal crest of *Conger* is reduced or totally absent. In addition, the opercular musculature, which attaches to the rear of this same crest in *Conger*, is much reduced in the Ophichthidae. Thus, the skull of the ophichthids, instead of ending posteriorly in an acute edge, usually tapers off more or less gradually into the vertebral column.

Certain other changes in the head skeleton appear to be related to the backward displacement of the quadrate in ophichthids. The maxillary, the posterior end of which abuts against the dentary in *Conger*, usually falls far short of this bone in ophichthids and, except in *Brachysomophis*, is attached to the mandible only by a long, slender, and sometimes ossified ligament. Also, in ophichthids, the palatopterygoid has lost its importance as a strut between the suspensorium and the skull, and has become more or less reduced and disarticulated.

In *Conger*, with forwardly suspended jaw and moderately well-developed opercular apparatus, the gill arches lie largely below the skull, and the gill openings are less than a skull length behind. In ophichthids, on the other hand, the gill arches lie mostly behind



the skull, and the gill openings are more than a skull length from its posterior border. The peculiar basketlike arrangement of the branchiostegal rays has doubtless been developed in ophichthids to shield this otherwise unsupported area of the gill arches. It seems anomalous that a similar arrangement has not been developed in other eel families with posteriorly placed gill arches.

The auditory bulla, though variable in the Ophichthidae, is always present. No trace of this structure is visible externally in the skull of *Conger*.

The pectoral girdle is less degenerate (hence more primitive) in *Conger*, which retains four actinosts, than in ophichthids, in which one actinost at most has been found and in which the girdle may be reduced to a cleithrum and supracleithrum.

Regan's chief osteological differentiation (1912) between the Congridae and Ophichthidae lay in the vestigial neural spines of the latter family. In addition, the intermuscular bones of ophichthids are well developed, and the pleural ribs are often laminar.

From this comparison it is plain that the Ophichthidae and *Conger* are very well separated. If other genera of the Congridae or other eel families are more closely related to the Ophichthidae, there is nothing in the literature to indicate it.

Within the Ophichthidae several minor lines of evolutionary development seem to be represented. It seems justified on zoological grounds (as well as from precedent) to remove *Muraenichthys*, subfamily Myrophinae, first (Gosline, 1950). This genus has two primitive features not found in the other genera examined: the dorsal and anal form an externally visible fin around the tip of the tail, and, in *M. cookei* at least, the suspensorium is somewhat forwardly directed. *M. cookei* also has a moderately short skull with roundish interorbital opening, and the ethmoid projects over the frontals as a rather broad, bilobed plate. In these two features *Muraenichthys* disagrees with *Conger* and with all but

*Myrichthys* of the Ophichthidae examined.

Within the subfamily Ophichthinae, one specialized group contains *Brachysomophis* and probably also *Ophisurus* (or *Oxystomus*). These two genera have developed, probably *via* *Ophichthus*, a protruding lower jaw, fanglike teeth, and an extremely long maxillary supported (as in some muraenids) by a strut of postorbital ossicles. These characters are probably all functional adaptations for fish-eating. In other respects (as well as in the low vertebral number) the skull of *Brachysomophis* resembles that of the weak-jawed *Caecula*.

Another group that can immediately be separated from other Ophichthinae contains *Myrichthys* and probably *Callechelys*. *Myrichthys* (Fig. 5) has a relatively short, high skull, vertically elongate interorbital opening, large orbitosphenoid, and broad, emarginate posterodorsal ethmoid projection. In these characters *Myrichthys* resembles *Muraenichthys*, though convergent evolution rather than close relationship would seem indicated. At any rate, *Myrichthys* and *Callechelys* differ from *Muraenichthys* and most other ophichthids in the large number of vertebrae and in having the relatively high dorsal commencing far forward on the head.

The remaining genera studied are all rather similar internally, though a *Machaerenchelys-Leiuranus-Phyllophichthus* group can be easily separated on tooth characters. In these three genera the vomerine teeth are few or absent and are replaced functionally by those of the maxillaries which have moved in toward the center of the upper jaw.

The last three genera to be dealt with are *Caecula*, *Cirrhimuraena*, and *Ophichthus*. Probably these are not closely interrelated, but I cannot place them with other generic groups. *Caecula* itself may be composite, as it is characterized merely by having the fins rudimentary or absent. (Jordan and Evermann [1896: 374] state, on what basis I do not know, that *Sphagebranchus* [= *Caecula*] "is the most simple in structure among the



Ophichthyidae [=Ophichthinae], as *Ophichthus* is probably the most specialized.") *Cirrhimuraena*, except for the fringed lip, seems to be a rather generalized type of ophichthid, possessing, among other things, a better-developed pectoral than any of the other genera examined. *Ophichthus*, as already mentioned, is probably on the evolutionary road to *Brachysomophis*; whether this is a primitive road for ophichthids is undeterminable.

#### TAXONOMY

Although internal structures must be taken into account in the basic classification of any group, particularly one as secondarily simplified as the eels, the identification and delimitation of genera and species in the group are normally based on external characters. This is particularly necessary in eels, in which the species are all too apt to be represented by unique specimens that cannot well be dissected.

The Ophichthidae in Hawaii may be recognized superficially by the fact that the fin and fin rays around the tip of the tail are either totally absent, or are much reduced as compared with the dorsal and anal fin rays immediately preceding them. In addition, the posterior nostril lies more or less below the eye, either on the inside or outside of the upper lip. The family is divided (Gosline, 1950, and this paper, above) into two subfamilies—the Myrophinae, with small rays visible externally around the tip of the tail, and the Ophichthinae, with the tail protruding as a finless fleshy point beyond the dorsal and anal. Inasmuch as I have no evidence that either of the two subfamilies is polyphyletic, the taxonomy of each will be discussed separately.

MYROPHINAE. The genera of Myrophinae have been dealt with briefly by Myers and Storey (1939) and by Schultz and Woods (1949). However, I have recently shown (Gosline, 1950, and in press) that among the genera mentioned in both of these papers there are

representatives of two quite different families. Thus, *Kaupichthys* and *Chilorhinus* (and presumably *Echelus* and *Garmanichthys*) belong in a family which has little except superficial similarity in common with the Myrophinae. Of the remaining genera probably belonging to the Myrophinae, Myers and Storey (1939: 157) list seven, but Schultz and Woods (1949: 170) reduce this number to two—*Myrophis* and *Muraenichthys*. I have already pointed out (Gosline, 1950) that *Garmanichthys bicollaris* Myers and Wade must almost certainly be removed from the genus *Muraenichthys*, as interpreted by Schultz and Woods. But even with *G. bicollaris* removed, some question arises as to whether these authors have not too broadly interpreted the limits of *Myrophis* and *Muraenichthys*. It appears to me that *Muraenichthys* of Schultz and Woods should at least be divided into subgenera, one of which—*Schultzidia*—is described below.

The circumtropical subfamily includes some 25 described species of small eels.

OPHICHTHINAE. The Ophichthinae comprises one of the largest of eel groups. The genera and species of the subfamily have never been adequately revised.

Difficulties of two main sorts have discouraged recent ichthyologists from revising the subfamily as a whole. First, the group is of circumtropical distribution, but is very inadequately represented in collections. Many of the species and a good number of genera have been based on unique specimens scattered among the museums of the world, and many of the species undoubtedly remain uncollected. Second, most of the characters by which more normal fishes are distinguished are lacking in some or all of the Ophichthinae, e. g., fins, scales, and gill rakers. This has resulted in many hopelessly inadequate descriptions which would have to be properly allocated by anyone reviewing the subfamily.

Each of the three most recent treatments of the subfamily *in toto* is more than 80 years old. Kaup (1856), in his synopsis of the apodal fishes, recognized and described a plethora of



genera (22) on completely insufficient, almost whimsical, bases. As all of Kaup's types, so far as I know, have never been re-examined, many of his generic and specific names remain unidentifiable. Bleeker (1865), in a brief paper reviewing the classification of all eel groups, recognized 8 genera of Ophichthinae. Günther (1870) further reduced the genera of the subfamily to 2, but recent workers have recognized many more.

Since Günther, the Ophichthinae has been investigated only piecemeal. Storey (1939) has redescribed the types of most of the species belonging to the genera *Callechelys* and *Bascanichthys*, but no other generic revisions have been attempted recently. On the other hand, the Ophichthinae of various parts of the world have been dealt with in faunistic reports. Most notable of these are probably those of Bleeker (1864) and Weber and de Beaufort (1916) for the Indo-Australian Archipelago and of Jordan and Davis (1892) for America and Europe.

Genera and species of Ophichthinae continue to be described almost every year—some well, many badly. The system of classification within the group—never adequate—is consequently now outdated and chaotic.

The Ophichthinae are found everywhere along the shores of tropical seas. In addition, some of them have been picked up at the surface of the ocean far from land; at least one, *Caecula cephalopeltis*, occurs in fresh water; and one, *Pisoodonophis boro*, is a pest in rice fields (Ramakrishna Ayyar, 1932). Most of the members are moderate to small wormlike forms, though several are large and have fang-like teeth. Most of the group seem to burrow in the sand with their tails. Some of these, e. g., *Callechelys luteus* in Hawaii, usually remain with the head and a small part of the body above the surface of the sand, while others, e. g., *Sphagebranchus platyrhyncha* in Hawaii, seem to live an almost completely subterranean existence, burrowing forward or backward through the sand with great ease and speed.

The account that follows deals with the 9 genera and 13 species of ophichthids known from the Hawaiian Islands, including Johnston Island. Specimens of all the species are either represented in the University of Hawaii Collection or have been examined in the Bishop Museum. Those represented in the University's collection have been illustrated. In the synonymies all Hawaiian records are listed, but those from elsewhere, except for the type, are not.

Certain principal taxonomic characters of the Hawaiian ophichthids are summarized in Table 2.

#### ARTIFICIAL KEY TO THE HAWAIIAN SPECIES OF OPHICHTHIDAE

- 1a. A fin with fin rays present, but reduced, around tip of tail. Species less than 18 inches in length; in Hawaiian forms dorsal originating nearer anus than gill openings, and pectoral fins absent. (Subfamily Myrophinae.)
  - 2a. Dorsal commencing over a head length (measured to gill opening) behind anus; body compressed, its depth about  $1\frac{1}{2}$  times its width; teeth lacking on intermaxillary (or premaxillary) and vomer (see Fig. 12a).
    1. *Muraenichthys* (*Schultzia*) *johnstonensis*
  - 2b. Dorsal commencing within a head length of the anus; body nearly cylindrical; teeth present on intermaxillary and vomer.
    - 3a. Dorsal commencing behind anus; cleft of mouth reaching well behind eye; vomerine teeth in 2 or 3 rows.
      2. *Muraenichthys* (*Muraenichthys*) *schultzei*
    - 3b. Dorsal origin over or ahead of anus; cleft of mouth reaching almost to posterior border of eye; vomerine teeth in a single, sometimes irregular, row (see Fig. 12b).
      3. *Muraenichthys* (*Muraenichthys*) *cookei*
- 1b. Tip of tail a hard, fleshy point, without fin. (Subfamily Ophichthinae.)
  - 4a. Body without traces of fins anywhere.
    - 5a. Snout more or less elliptical in cross section, without lateral ridges; head (measured to gill opening) contained 15 to 20 times in the extremely elongate body; posterior nostril opening on outside of upper lip (Fig. 14a).
      4. *Caecula* (*Sphagebranchus*) *flavicauda*
    - 5b. Snout with well-developed lateral ridges, forming a flattened triangle in cross section; head contained about 10 times in body length; posterior nostril opening on inside of upper lip, the opening not visible externally.
      5. *Caecula* (*Sphagebranchus*) *platyrhyncha*



4b. Dorsal and anal present, though sometimes low and inconspicuous.

6a. Dorsal commencing well ahead of gill openings. Lower jaw inferior.

7a. Pectorals absent; tail (measured from anus) shorter than trunk (measured from gill openings to anus). Dorsal high, anal low.

6. *Callechelys luteus*

7b. Pectorals present; tail longer than trunk.

8a. Pectoral short, rounded, its length less than the width of its base; upper lip not fringed.

9a. Color pattern consisting of several longitudinal series of spots on sides.

7. *Myrichthys maculosus*

9b. Color pattern consisting of a series of about 29 dark saddles of varying depth, but on an average reaching down approximately to the lateral line.

8. *Myrichthys bleekeri*

8b. Pectoral considerably longer than broad; edge of upper lip fringed.

9. *Cirrhimuraena macgregori*

6b. Dorsal commencing about over or behind the gill openings.

10a. Lower jaw inferior; upper lip without a series of papillae.

11a. Anterior nostrils with leaf-like appendages (Fig. 17).

10. *Phyllophichthus xenodontus*

11b. Anterior nostrils without leaf-like appendages.

12a. Body plain. Eye about equal to snout length. (This species, probably from moderately deep water, will be dealt with in a report on the fishes killed by the Mauna Loa lava flow of 1950.)

11. Ophichthidae, new species

12b. Body with well-marked spots or saddles.

13a. Mouth small and distinctly inferior, the snout projecting beyond tip of lower jaw by more than two eye diameters; teeth small, completely lacking on vomer.

12. *Leiuranus semicinctus*

13b. Mouth large, little inferior, the snout projecting by less than an eye diameter; teeth large, sharp, present on vomer. Dorsal commencing approx-

imately over gill opening.

13. *Ophichthus polyophthalmus*

10b. Lower jaw somewhat projecting; upper lip papillate or fringed. Teeth long, fang-like; eye well forward of center of cleft of mouth; dorsal commencing well behind gill opening.

14. *Brachysomophis henshawii*

## MURAENICHTHYS Bleeker

As already mentioned, the most recent paper on the genus (Schultz and Woods, 1949) interprets the limits of the genus *Muraenichthys* very broadly, including in it several genera usually recognized as distinct by previous authors. In the same paper, Schultz and Woods describe a species, *Muraenichthys johnstonensis*, which expands still further the limits of the genus as understood by them. It seems to me that *M. johnstonensis* deserves at least subgeneric rank, which it is given here under the name *Schultzidia*.

### *Schultzidia* new subgenus

SUBGENOTYPE: *Muraenichthys johnstonensis* Schultz and Woods (1949: 172).

The species of this subgenus, as Schultz and Woods point out, differ immediately from other species of *Muraenichthys* in totally lacking teeth on the intermaxillary and vomer. Vomerine teeth are usually well developed in the Ophichthidae, and their absence has long been considered a generic character in the group—in *Leiuranus*, even by Günther (1870: 54), Schultz (1943: 14), and others; and in *Abilia* by Jordan and Davis (1892: 639), Myers and Storey (1939: 158), and Wade (1946: 199). On the other hand, *Abilia* has been synonymized under *Myrophis*, a genus typically with vomerine teeth, by Parr (1930: 8), Hildebrand (in Longley and Hildebrand, 1941: 17), and Schultz and Woods (1949: 171). The absence of intermaxillary teeth in *Schultzidia* is, so far as I know, unique among the Ophichthidae, though the dentition or



TABLE 2

SYNOPSIS OF CERTAIN PRINCIPAL TAXONOMIC CHARACTERS OF HAWAIIAN OPHICHTHIDAE

SPECIES	DORSAL ORIGIN	PECTORAL	TEETH	UPPER LIP
MYROPHINAE				
<i>Muraenichthys johnstonensis</i>	Behind anus	Absent	Villiform on maxillaries, absent on intermaxillary and vomer	Not fringed
<i>Muraenichthys schultzei</i>	Behind anus	Absent	Granular; mostly biserial on jaws and on vomer	Not fringed
<i>Muraenichthys cookei</i>	Slightly before anus	Absent	Conical; uniserial on vomer and mandible, biserial on maxillary	Not fringed
OPHICHTHINAE				
<i>Caecula flavicauda</i> and <i>C. platyrhyncha</i>	Fin absent	Absent	Small, sharp, depressible, and uniserial throughout	Not fringed
<i>Callechelys luteus</i>	Ahead of gill opening; high	Absent	Conical; uniserial in jaws, biserial on vomer	Grooved but not fringed
<i>Myrichthys bleekeri</i> and <i>M. maculosus</i>	Ahead of gill opening; high	Short, rounded	Granular; mostly biserial	Grooved but not fringed
<i>Cirrhimuraena macgregori</i>	Ahead of gill opening; low	Elongate	In adult bluntly conical; on jaws biserial, on vomer in a band	Fringed
<i>Phyllophichthus xenodontus</i>	Over pectoral base; low	Elongate	Absent from vomer; in jaws conical, uniserial, those of mandible directed laterally	Grooved but not fringed
<i>Leiuranus semicinctus</i>	Over pectoral base; low	Roundish	Absent from vomer; small, conical, uniserial elsewhere	Grooved but not fringed
<i>Ophichthus polyophthalmus</i>	Over pectoral base	Somewhat elongate	Large, sharp, uniserial throughout	Not fringed
<i>Brachysomophis henshawi</i>	Somewhat behind pectoral base	Roundish	Fang-like; uniserial on vomer and mandible; biserial on maxillary	Fringed or papillate

lack of it in this part of the mouth is undescribed for several of the species of *Muraenichthys*.

Schultz and Woods, apparently from a re-examination of the types, place *M. retropinnis* in the same group with *M. johnstonensis*. There is nothing, however, in Fowler's original description (1934: 277) to indicate whether this placement is correct.

DERIVATION OF NAME: *Schultzidia*, for Leonard P. Schultz, Curator of Fishes, U. S. National Museum.

1. *Muraenichthys (Schultzidia) johnstonensis* Schultz and Woods

Fig. 12a

*Muraenichthys johnstonensis* Schultz and Woods (1949: 172, fig. 1 and tab. 1) (Johnston Island and Bikini Atoll).

MATERIAL EXAMINED: 1 specimen, 160 mm. in total length, from the reef at Midway and 2 specimens, 84 and 102 mm., from Oahu, in the University of Hawaii Collection.

The Midway specimen agrees in all essen-



tial respects with the excellent description of the species given by Schultz and Woods. I can find in the Midway specimen no embedded teeth on the premaxillary, suggested as a possibility by these authors; in fact, an adnate upper lip covers the area in which such teeth might be expected.

The species is known only from the records listed above.

2. *Muraenichthys* (*Muraenichthys*) *schultzei* Bleeker

*Muraenichthys schultzei* Bleeker (1857: 366) (South Java); Fowler and Ball (1925: 5) (Johnston Island); Fowler (1928: 41) (Johnston Island).

MATERIAL EXAMINED: 8 specimens, 77–99 mm., of the 12 recorded by Fowler and Ball and by Fowler from Johnston Island in the Bishop Museum.

Except for the specimens listed above, the species is unknown in the Hawaiian Islands.

3. *Muraenichthys* (*Muraenichthys*) *cookei* Fowler

Figs. 3, 10*a*, 12*b*, 13

?*Muraenichthys gymnopterus* [non Bleeker], Fowler (1928: 40) (Hawaiian Islands).

*Muraenichthys cookei* Fowler (1928: 41, fig. 9) (Oahu); Schultz and Woods (1949: 172).

*Muraenichthys laticaudata*, Schultz [in part] (1943: 53); Fowler (1949: 44).

MATERIAL EXAMINED: 10 specimens from Oahu, 1 from Kauai, and 7 from Midway, all in the University of Hawaii Collection;

Fowler's type of the species in the Bishop Museum.

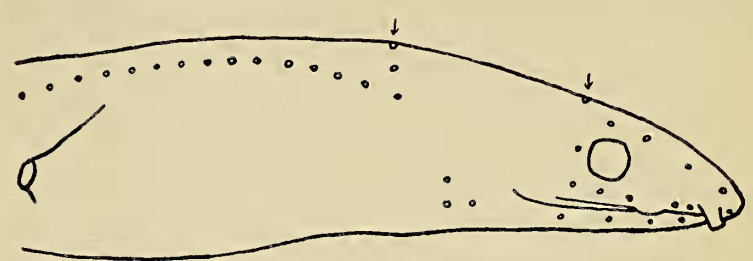


FIG. 13. Head of *Muraenichthys* (*Muraenichthys*) *cookei*. As in subsequent figures, the lateral line pores of the head are shown and those of the middorsal line are indicated by arrows.

The distinction between *M. cookei* and *M. laticaudata* is not as clear as one might wish or as Schultz and Woods's key might indicate. In my material of *M. cookei* the dorsal usually commences as much as one-third of a head length ahead of the anus, but is sometimes directly over the anus. In *M. laticaudata* the dorsal usually begins behind, but sometimes over or even slightly before the anus. There are no other readily apparent characters to distinguish the two species.

*M. cookei* is limited to the Hawaiian Islands and is doubtless a derivative of *M. laticaudata*. The Hawaiian offshoot is not rare. It apparently buries itself in sand-filled pockets on a coralline-rock bottom.

CAECULA Vahl

Vertical fins absent or feebly developed; if present, the dorsal commences behind the level of the gill openings. No pectoral fins in Pacific species.

Subgenus *Caecula*: with at least rudimentary vertical fins.

Subgenus *Sphagebranchus*: wholly finless.

The definition, and consequently the limits, of the genus *Caecula* are agreed upon by no two authors as far as I know. Whether the generic characterization given above is any better than many others previously proposed can be determined only from an examination of the many species in the group.

4. *Caecula* (*Sphagebranchus*) *flavicauda* (Snyder)

Table 3 and Fig. 14*a,c*

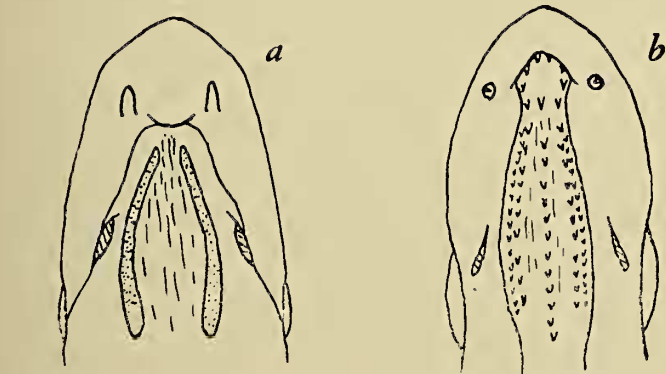


FIG. 12. *a*, Roof of mouth of *Muraenichthys* (*Schultzidia*) *johnstonensis*; *b*, of *Muraenichthys* (*Muraenichthys*) *cookei*.



*Sphagebranchus flavicaudus* Snyder (1904: 516, pl. 2, fig. 4) (from between Maui and Lanai in 21 to 28 fathoms); Jordan and Evermann (1905: 80, pl. 5, fig. 2) (northeast coast of Hawaii in 50 to 60 fathoms).

A fourth specimen of this species in the University of Hawaii Collection is 516 mm. in length and was obtained from shallow water on the coral reef in Hanauma Bay, Oahu.

The posterior nostril of this species opens as an elliptical hole in the outside of the upper lip; the opening is partly covered by a flap (Fig. 14a). According to Weber and de Beaufort's classification of the ophichthids (1916: 280) *C. flavicauda* would key out to the genus *Hemerorhinus*. However, *Hemerorhinus* Weber and de Beaufort appears to be one of the less justified generic names in the *Caecula* group.

5. *Caecula (Sphagebranchus) platyrhyncha*  
new species

Table 3 and Figs. 1, 14b,d

?*Caecula flavicauda* [non *Sphagebranchus flavicaudus* Snyder], Fowler (1928: 47) (Kahala, Oahu; one headless specimen).

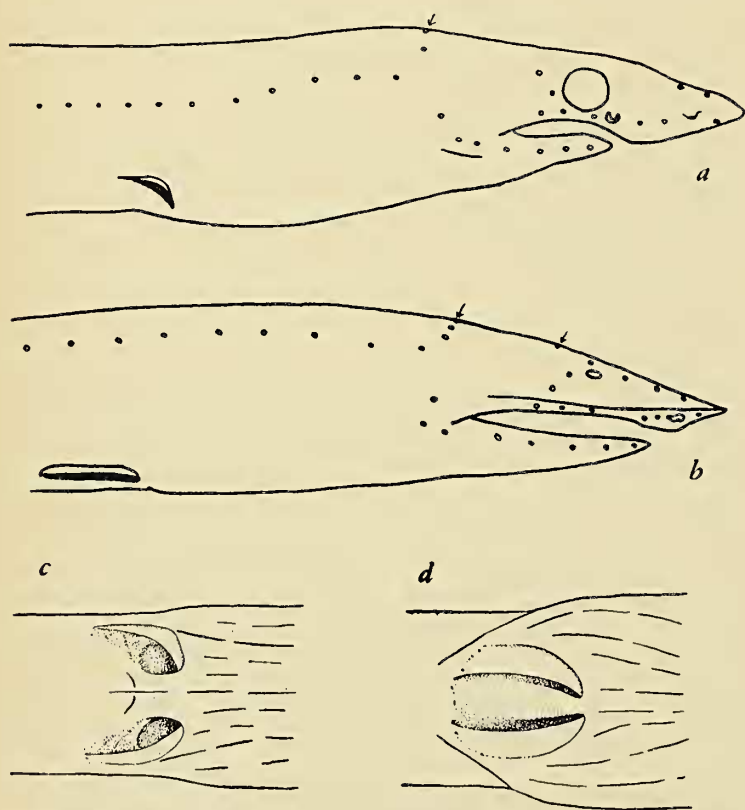


FIG. 14. a, Head, and c, ventral view, of gill openings of *Caecula (Sphagebranchus) flavicauda*; b and d, same views of *Caecula (Sphagebranchus) platyrhyncha*.

HOLOTYPE: U.S.N.M. No. 152543, 430 mm. in length, taken in a shallow-water poison station at Hauula Park, north shore of Oahu, T. H., on June 28, 1949, by Gosline and party.

PARATYPES: University of Hawaii No. 316, 10 specimens, 155 to 365 mm. in length, taken with the holotype; University of Hawaii No. 958, 9 specimens, 305–375 mm., taken by Needham and Welsh, July, 1949, at Hanalei, Kauai; U.S.N.M. No. 152544, 3 specimens, 164–355 mm., from a tide pool opposite Pupukea, Waimea coast, Oahu, T. H., collected by Gosline and party, Nov. 22, 1948; Bernice P. Bishop Museum No. 5543, 1 specimen, 455 mm., from Laie, north coast of Oahu, Dec. 17, 1949, collected by Sam Cooke.

A relatively short, sturdy species for the subgenus, with both ends sharply pointed. Snout forming a flattened triangle in cross section, with well-developed lateral ridges; remainder of body more or less cylindrical. Anus somewhat forward of center of length. Eye minute, embedded, and little protruding, but readily visible from the exterior, situated approximately over center of distance from tip of snout to rictus and over forward part of cleft of the inferior mouth. Anterior nostril within a very slightly raised rim on the flattened lower surface of the rostrum, its diameter about equal to the width of the eye. Posterior nostrils opening from the inside of the upper lip into the mouth, slightly before eye, not visible from the exterior. Upper lip with a deep median groove, within which lie the intermaxillary teeth. All the teeth depressible backwards, apparently not implanted in sockets in the jaws, uniserial throughout. About 5 teeth in the intermaxillary, 11 on the vomer, 15 on each maxillary, and about 20 on each side of the lower jaw. Sensory pores of head and body very prominent. Gill openings close together (separated forward by an isthmus about an eye diameter in width), nearly parallel (lines projected forward from their inner surfaces



TABLE 3

PROPORTIONAL MEASUREMENTS (EXPRESSED AS THOUSANDTHS OF THE TOTAL LENGTH) AND PORE NUMBERS FOR HAWAIIAN SPECIES OF *Caecula*

CHARACTER	<i>Caecula platyrhyncha</i>							<i>C. flavicauda</i>
	HOLOTYPE	PARATYPES, U. H. 316						U. H. 378
Total length in mm. . . . .	430	365	315	274	251	207	155	413
Snout to anus. . . . .	440	424	422	442	433	421	438	538
Snout to gill opening. . . . .	90	87	86	87	86	90	91	46
Snout to rictus. . . . .	32	31	31	36	32	34	33	17
Snout to tip of upper jaw. . . . .	13	13	10	12	14	13	13	9
Snout length. . . . .	17	15	15	18	17	23	19	10
Eye diameter. . . . .	3	3	3	4	5	4	5	3
Greatest diameter of gill opening. . . . .	16	16	19	11	14	14	15	7
Least width of isthmus. . . . .	3	2	3	4	3	4	6	3
Depth of head. . . . .	29	29	29	34	30	30	37	17
Depth of anus. . . . .	21	24	29	27	21	20	19	9
Width of head. . . . .	28	28	32	29	27	26	36	12
Width of anus. . . . .	22	22	29	26	23	23	22	11
Lateral-line pores on body. . . . .	118	121	120	121	121	119	120	153

would meet at an angle of about 25°), and with well-developed membranes covering the outer portions (Fig. 14*d*). Color uniformly pinkish. The specimens have all been taken from sand in shallow water, in which they were originally completely buried.

*C. platyrhyncha* can be immediately separated from the only other Hawaiian species of the genus by the shorter, more robust body, flat snout, and interior exit for the posterior nostrils. Distinguishing it from other nominal species is more difficult, for a large number of these wormlike, rather characterless eels have been described in a completely undiagnostic way. One such is the subgenotype—*Sphagebranchus rostratus* Bloch (1795)—which has the added feature of being of uncertain origin. (Concerning Bloch’s type, Jordan and Evermann, 1896: 373, state: “According to Bloch his type came from the East Indies. Schneider (1801) corrects the locality to ‘rivers of Surinam’. We have no means of knowing which record is correct.”). However, Bloch states that the anus is in the middle of the body. His plate shows no membranes over the gill opening, and the eye over the middle of the cleft of the mouth. Bloch’s species differs from *C. platyrhyncha* in all three of these characters.

There seems to be no described species in Oceania to which *C. platyrhyncha* is closely related. In the Indo-Australian region *Caecula vulturus* (Weber and de Beaufort, 1916: 319), from near Sumatra, appears to be most similar. However, *C. vulturus* is said to be a somewhat slenderer fish with a conical snout and with the posterior nostril opening below the eye. *Sphagebranchus selachops* Jordan and Gilbert from Cape San Lucas, the most similar species from the Eastern Pacific, appears, from Myers and Wade’s treatment (1941: 75), to lack membranes over the gill openings.

DERIVATION OF NAME: *platy*, flat; *rhyncha*, snout.

CALLECHELYS Kaup

For the purposes of the present paper the genus may be sufficiently defined as follows: Dorsal and anal fin present, the former commencing ahead of the gill openings. Pectoral fins absent.

6. *Callechelys luteus* Snyder

Fig. 15*a*

*Callechelys luteus* Snyder (1904: 517, pl. 3, fig. 5) (Molokai); Jordan and Evermann (1905: 86, pl. 8, fig. 1) [on the type]; Storey (1939: 69, tab. 1, fig. 2) [on the type].



*Ophichthys marmorata*, Günther (1910: 404) (Hawaii).

*Callechelys marmoratus*, Fowler (1928: 43) (Honolulu market).

MATERIAL EXAMINED: 2 specimens from Oahu, 1090 and 560 mm. in total length. The larger was grabbed by hand by Mr. V. E. Brock as it rested mostly buried in the sand; the smaller swam into a night light.

To enable comparison with the data on the genus assembled by Storey (1939), the following characters of the two specimens mentioned above are given, those for the smaller in parentheses. Greatest depth 40.8 (49.6), head to gill opening 18.5 (18.8), trunk 1.8 (1.9), and tail contained 2.5 (2.3) times in total length; head 10.0 (9.7) and tail 1.3 (1.2) in trunk; snout to rictus 3.6 (3.9) and snout to dorsal origin 2.8 (2.8) in head; distance between gill openings 1.3 (1.2) in length of gill openings; angle of gill openings  $130^\circ$  ( $125^\circ$ ). In these characters my two specimens check far better with Storey's data on *C. luteus* than on *C. marmoratus* or *C. guichenotii*.

#### MYRICHTHYS Girard

In the Hawaiian region the genus may be sufficiently distinguished as follows: Dorsal

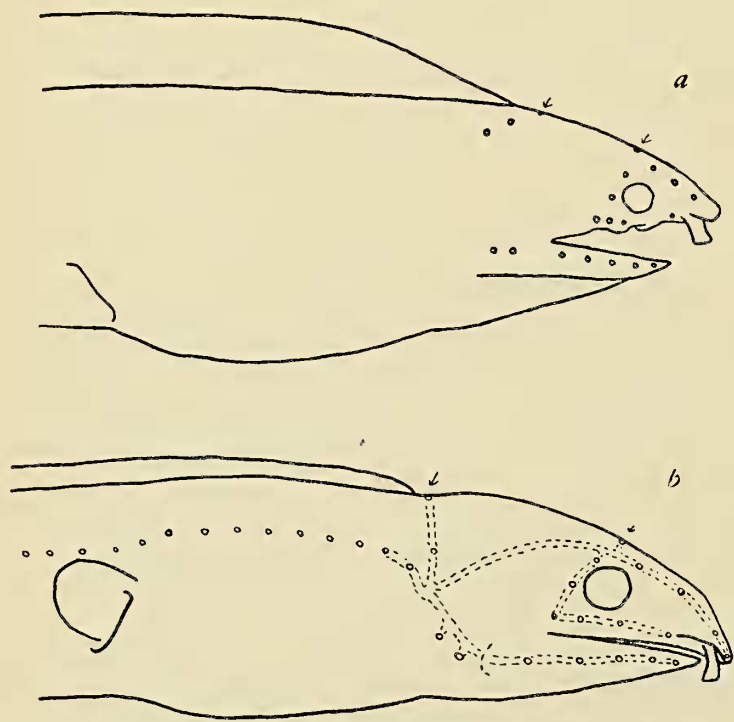


FIG. 15. *a*, Head of *Callechelys luteus*, and *b*, of *Myrichthys maculosus*, with the lateral line system of the head indicated.

commencing forward of the gill openings. Pectoral present, its base broader than its length. Teeth blunt and granular.

#### 7. *Myrichthys maculosus* (Cuvier)

Figs. 5, 7, 8, 9, 15*b*

*Muraena maculosa* Cuvier (1817: 232) (European seas?).

*Pisoodonophis magnifica* Abbott (1861:476) (Hawaiian Islands).

*Ophichthys stypurus* Smith and Swain (1882: 120) (Johnston Island).

*Myrichthys magnificus*, Fowler (1901: 494, pl. 18, fig. 3) [on Abbott's type]; Jordan and Evermann (1905: 84) (Hawaiian Islands).

*Myrichthys stypurus*, Jordan and Evermann (1905: 85, fig. 19) [on Smith and Swain's type].

*Ophichthys maculosus*, Günther (1910: 40) (Hawaiian Islands).

*Myrichthys maculosus*, Fowler and Ball (1925: 6) (Johnston Island); Fowler (1928: 43) (Johnston Island and Honolulu).

MATERIAL EXAMINED: 13 specimens from Oahu and 1 from Midway in the University of Hawaii Collection; 1 specimen from Honolulu in the Bishop Museum.

This species seems to be distributed from the Red Sea to Hawaii. It has been taken in the Phoenix (Schultz, 1943: 14) and Line Islands (Fowler, 1927: 5) south of Hawaii, as well as at Johnston Island.

#### 8. *Myrichthys bleekeri* substitute name

*Ophisurus fasciatus* var. *semicinctus* Bleeker [non *O. semicinctus* Lay and Bennett (1839: 66) non *O. semicinctus* Richardson (1844: 99)] (1864: 64) (Indonesia).

*Myrichthys colubrinus*, Fowler and Ball (1925: 5) (Johnston Island); Fowler (1928: 42) (in part; the Johnston Island specimens).

MATERIAL EXAMINED: 8, 335–385 mm., of the 12 specimens recorded by Fowler and Ball and by Fowler from Johnston Island, in the Bishop Museum Collection.



These specimens agree well with the diagnosis of this species as given by Schultz (1943: 12).

The records cited are the only ones for the species in the Hawaiian Islands. Schultz (1943: 12) has taken it at Palmyra.

Bleeker's original name is a homonym, for which a substitute is here proposed.

### CIRRHIMURAENA Kaup

Dorsal and anal low, the dorsal beginning before, over, or behind the gill openings. Pectorals well developed. Upper lip with a fringe. No canines, the maxillary and vomerine teeth either biserial or in bands.

*Cirrhimuraena* is here broadly defined. Whether all the species included in the definition are congeneric or even monophyletic is impossible to say without examination of specimens. They appear to fall into three groups, for each of which a generic name has been proposed as follows:

*Cirrhimuraena* Kaup (1856: 27). Dorsal commencing over or behind gill openings. Pectorals elongate. Eye forward of center of cleft of mouth. Maxillary teeth in bands. Included species: *C. tapeinopterus*, *chinensis*, and *chilopogon*, reviewed in Weber and de Beaufort (1916: 291).

*Jenkinsiella* Jordan and Evermann (1905: 83). Dorsal commencing well ahead of gill opening. Pectorals elongate. Eye about over center of cleft of mouth. Maxillary teeth biserial. Included species: *Microdonophis macgregori* Jenkins (1904: 422) and *Jenkinsiella oliveri* Seale (redescribed by Herre, 1923: 165).

*Calamuraena* Whitley (1944: 261). Dorsal commencing well ahead of gill openings. Pectorals short, rounded. Eye more or less over center of cleft of mouth. Maxillary teeth mostly biserial. Included species: *Ophichthys calamus* Günther (1870: 74).

#### 9. *Cirrhimuraena macgregori* (Jenkins)

Figs. 6, 10*b*, 16

*Microdonophis macgregori* Jenkins (1904: 422,

fig. 2) (Maui); Jordan and Evermann (1905: 82, fig. 18) [on the type].

\**Ophichthys calamus*, Fowler (1928: 45) (Maui).

MATERIAL EXAMINED: 4 specimens from Oahu and 2 from Hawaii in the University of Hawaii Collection; 1, recorded above by Fowler, from Maui in the Bishop Museum.

Contrary to the descriptions of Jenkins, Jordan and Evermann, and Fowler, this species does not have the teeth "in a single series on vomer and in jaws." In the larger University of Hawaii specimens, 188–338 mm., the teeth on the vomer are in several series, particularly toward the rear (Fig. 6*b*); those in the jaws are partly uniserial, partly biserial. In the Maui specimen, 131 mm. long, the teeth on the vomer are biserial behind, uniserial in front, and those on the jaws appear as single irregular rows. In other respects my specimens agree with the descriptions cited above. The fringe on the upper lip is somewhat better developed than is indicated in Jenkins' figure, reissued in Jordan and Evermann.

That Fowler erred in synonymizing this species with *Ophichthys calamus* Günther is clearly indicated by Whitley's redescription and figure of the latter species (1944: 261, fig. 6). Actual relationships appear to be closer between *C. macgregori* and *C. oliveri* (Seale) as redescribed by Herre (1923: 165, pl. 2, fig. 2). However, *C. oliveri* is said to have the "vomerine teeth in two rows, merging into one row posteriorly." Herre's plate shows the pectorals as tapering to a point, which also is not true of *C. macgregori*.

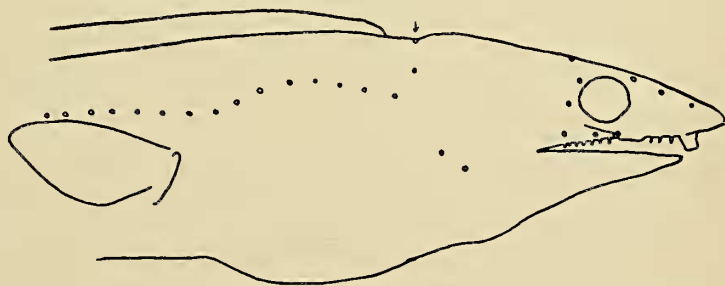


FIG. 16. Head of *Cirrhimuraena macgregori*.



# PHYLLOPHICHTHUS new genus

GENOTYPE: *Phyllophichthus xenodontus*, new species.

Head and body subcylindrical, becoming compressed toward tip of tail. Anus about at center of length. Dorsal and anal low, discontinuous around tip of tail which protrudes as a fleshy point. Dorsal commencing over rear of pectoral bases. Pectorals well developed, elongate. Gill openings round orifices opening onto lower part of pectoral bases. Branchiostegal rays numerous, those of the two sides overlapping. Mouth inferior to the long, tapering snout. Anterior nostrils with posterior borders extending downward into leaflike appendages. Posterior nostrils opening into mouth under a broad, infolded flap which is delimited on the outside of the upper lip as a groove below the anterior border of the eye. Two rows of conical teeth on the intermaxillary plate. A single row of smaller teeth on the inner border of each maxillary. No vomerine teeth. Mandibular teeth large, uniserial, well outside of the maxillary teeth, and projecting directly laterally.

Both the leaflike appendages of the anterior nostrils and the dentition of this genus will distinguish it from all other ophichthids. Nasal appendages, though common in the Muraenidae, are little developed elsewhere in the family Ophichthidae, though flaring, tubular nares are indicated for *Chlevastes* by Aoyagi (1943?: 16, fig. 5). In dentition *Phyllophichthus* most closely resembles *Leiuranus*, but the latter genus has normal, upright mandibular teeth. *Phyllophichthus* would appear to be a specialized relative of the *Leiuranus-Machaerenchelys* stock.

DERIVATION OF NAME: *phyll*, leaf; *Ophichthus*, the type genus of the family.

## 10. *Phyllophichthus xenodontus* new species

Fig. 17a,b

HOLOTYPE: University of Hawaii No. 318,

240 mm. in total length, taken in a poison station from shallow water at Hauula Park, Oahu, T. H., June 28, 1949, by Gosline and party.

DESCRIPTION (all measurements given as thousandths of the standard length): Distance from tip of snout to anus 512, to gill opening 96, to dorsal origin 101, to tip of lower jaw 10, to eye 28; greatest depth 31, depth at anus 22; greatest width 25, width at anus 20; eye 11; fleshy interorbital 12; length of nasal flap 7; cleft of mouth 38; greatest diameter of gill opening 9; width of pectoral base 9; and length of pectoral 26.

Pores in lateral line about 160.

Snout long, tapering to a conical point. Eye well developed, its posterior border nearly over rictus. Cleft of the inferior mouth horizontal, long, and narrow. Groove on under surface of snout (in which lie the intermaxillary teeth) extending nearly to tip of snout. Anterior nostrils about at level of tip of lower jaw, close together, their flaps touching one another. Intermaxillary teeth well developed, conical, arranged as 5 pairs in parallel longitudinal rows. About 4 weak teeth on the inner edge of each maxillary before posterior nostril, 4 or more even weaker embedded teeth behind. Lower jaw with a row of some 18 strong laterally directed teeth on each side; these rows not continued forward around the toothless symphysis. Color of

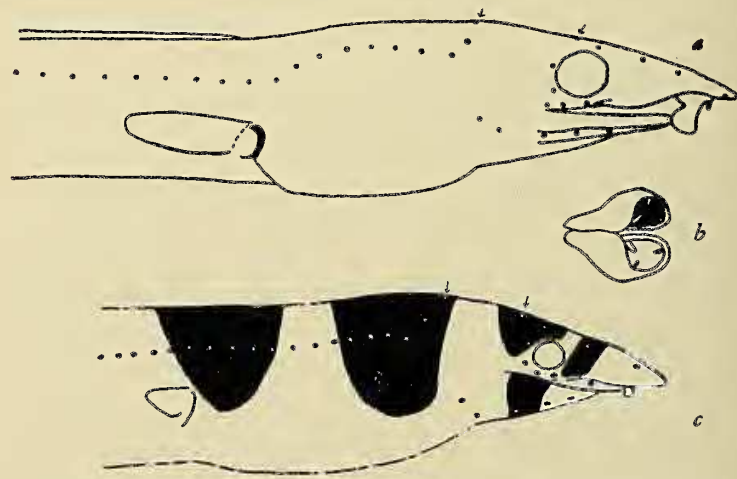


FIG. 17. a, Head and b, inferior view of anterior nostrils of *Phyllophichthus xenodontus*; c, head of *Leiuranus semicinctus*.



head and body in life plain greenish, darker above.

DERIVATION OF NAME: *xen*, strange; *odontus*, toothed.

#### LEIURANUS Bleeker

Vomerine teeth lacking. Dorsal beginning well behind head. Pectorals small. No nasal appendage.

One species: *Leiuranus semicinctus*.

#### 12.<sup>3</sup> *Leiuranus semicinctus* (Lay and Bennett)

Figs. 4, 17c

*Ophisurus semicinctus* Lay and Bennett (1839: 66, pl. 4, fig. 4) (Oahu).

*Leiuranus semicinctus*, Fowler (1901: 494) (Hawaiian Islands); Snyder (1904: 516) (Honolulu); Fowler and Ball (1925: 6) (Johnston Island).

MATERIAL EXAMINED: 2 specimens from Oahu in the University of Hawaii Collection; 2 specimens from Oahu and 2 from Johnston Island in the Bishop Museum Collection.

Among Hawaiian forms, the color pattern of this fish could be confused only with that of *Myrichthys bleekeri*.

#### OPHICHTHUS Thunberg and Ahl

For purposes of the present paper *Ophichthus* may be defined as follows: Dorsal fin commencing over or behind gill opening. Pectorals present. Conical teeth present on jaws and vomer. Lower jaw somewhat inferior.

#### 13. *Ophichthus polyophthalmus* (Bleeker)

*Ophichthys polyophthalmus* Bleeker (1864: 43) (Amboina); Fowler (1927: 5) (Kahoolawe); Fowler (1928: 45) (Honolulu market).

*Microdonophis fowleri* Jordan and Evermann (1904: 164) (Honolulu market); Jordan and Evermann (1905: 82, pl. 6) (Honolulu

market); Jordan and Snyder (1907: 208) (Honolulu market).

*Microdonophis polyophthalmus*, Jordan and Snyder (1907: 208) (Honolulu market).

MATERIAL EXAMINED: 1 specimen in two pieces, recorded by Fowler (1928), from Kahoolawe, in the Bishop Museum.

The teeth in this specimen are large and sharp, in very regular uniserial series on the jaws and vomer. I can find little trace of the fringe on the upper lip described by Jordan and Evermann, and the lower jaw is more inferior than shown on their plate.

#### BRACHYSOMOPHIS Kaup

Lower jaw protruding beyond the upper. Large canine teeth in the jaws and on vomer. Eye far forward on snout. Upper lip fringed.

The taxonomic problems in regard to *Brachysomophis* have recently been pointed out by Schultz (1943: 17).

#### 14. *Brachysomophis henshawi* Jordan and Snyder

Figs. 2, 18

*Brachysomophis henshawi* Jordan and Snyder (1904: 910) (Honolulu); Jordan and Evermann (1905: 84, pl. 7) [on the type]; Fowler (1928: 46) [on the type].

MATERIAL EXAMINED: 1 specimen, without locality but most probably from Oahu, inherited by the University of Hawaii Collection.

#### DISTRIBUTION OF THE OPHICHTHIDAE IN THE HAWAIIAN ISLANDS

The records of the Ophichthidae in the Hawaiian Islands are in agreement with the

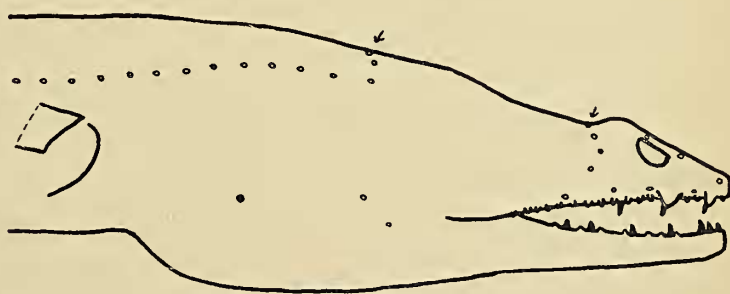


FIG. 18. Head of *Brachysomophis henshawi*. The pectorals of the only available specimen are broken.

<sup>3</sup>For reference to species 11, see key, page 309.



little that is already known of fish distribution in these islands. The predominance of records from Oahu simply reflects the overwhelming proportion of collecting done there. The question remains unsolved whether the Hawaiian fish fauna arrived originally in the low leeward islands and moved from there into the high windward islands after they arose (as postulated for much of the terrestrial biota by Zimmerman, 1948) or whether the present fish fauna came directly to these high islands. That Johnston Island has been a way point in the immigration, and perhaps the emigration, of much, at least of the Hawaiian, fish fauna is indicated by the Ophichthidae, as well as by numerous other groups. The relationship, if any, between the ophichthid eels (and other fish groups) of the Hawaiian chain and those of Wake, as demonstrated by Edmondson (1925) for Crustacea, remains unknown.

The known distribution of Hawaiian ophichthids is shown in Table 4. Such a table may be very misleading for two reasons. (1) It is strongly weighted by the incidence of collecting in the various areas. The low number of recorded species from the leeward Hawaiian Islands, for example, is undoubtedly due to inadequate collecting. Actually, for the areas listed, collecting has probably been done most adequately on the high Hawaiian

Islands, less so on the Phoenix and Line Islands, even less on Johnston Island, and least adequately on the leeward Hawaiian group. (2) Such a table may well reflect an author's predilection for "splitting" or "lumping." Of the species listed in Table 4, *Callechelys luteus* and *Muraenichthys cookei* have been and could well be considered synonyms of more wide-ranging species. On the other hand, the Hawaiian specimens of the species here called *Ophichthus polyophthalmus*, described from the East Indies, may well be a distinct species.

Nevertheless, the table does bring out several points. (1) The fact that 7 out of 13 species (and one genus) of Ophichthidae known from the Hawaiian Islands have not been recorded elsewhere indicates the high degree of differentiation of the Hawaiian fish fauna. A similar but probably somewhat lower degree of endemism holds for other fish groups. (2) The species endemic to Hawaii have not yet been taken at Johnston Island. Two species taken at Johnston have not yet been taken elsewhere in the Hawaiian group, but all four species recorded from Johnston are widely distributed in the Indo-West Pacific. This would point—insecurely to be sure—to Johnston Island as a portal for the immigration into Hawaii of wide-ranging Pacific species, but not as a portal for emigra-

TABLE 4  
DISTRIBUTION OF HAWAIIAN OPHICHTHIDS

SPECIES	HAWAIIAN ISLANDS			PHOENIX AND LINE ISLANDS	ELSEWHERE
	HIGH	LEEWARD	JOHNSTON		
1. <i>Muraenichthys johnstonensis</i> . . . .	X	X	X		Bikini
2. <i>Muraenichthys schultzei</i> . . . . .			X	X	Red Sea to Ellice Islands
3. <i>Muraenichthys cookei</i> . . . . .	X	X			
4. <i>Caecula flavicauda</i> . . . . .	X				
5. <i>Caecula platyrhyncha</i> . . . . .	X				
6. <i>Callechelys luteus</i> . . . . .	X				
7. <i>Myrichthys maculosus</i> . . . . .	X	X	X	X	Red Sea to Oceania
8. <i>Myrichthys bleekeri</i> . . . . .			X	X	East Indies
9. <i>Cirrhimuraena macgregori</i> . . . .	X				
10. <i>Phyllophichthus xenodontus</i> . . . .	X				
*12. <i>Leiuranus semicinctus</i> . . . . .	X		X	X†	Southern Africa to Samoa
13. <i>Ophichthus polyophthalmus</i> . . . .	X				East Indies and ?Society Islands
14. <i>Brachysomophis benshawii</i> . . . .	X				

\* For reference to eleventh species, still unnamed, see key, page 309.  
† Taken by the author at Hull Island.



tion, i. e., in Simpson's terminology (1940: 148) Johnston would appear to be a primarily one-way "filter bridge" for fishes. This also is borne out in other fish groups. (3) There is no close relationship between the Hawaiian ophichthids and those of the West Coast of America. This, also true of other small fishes, checks well with Ekman's "East Pacific barrier" hypothesis (Ekman, 1935: 105).

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